Development of a Distributed Watershed Water Quality Model

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Discussion Items

- System-Wide Water Resources Research Program (SWWRP)
- Watershed Modeling System (WMS) and Gridded Surface Sub-surface Hydrologic Analysis (GSSHA) model
- SWWRP-NSM Kinetic Modules
- Eight Mile Watershed Case Study
- Future Development Activities

SWWRP Nutrient Module Development

Research Effort

As Environmental Problems have become more complex and system oriented, it has become necessary to describe nutrient fate and transport on a more physical basis.

In order to evaluate individual projects in sufficient detail and at the same time evaluate projects on a system wide basis, complex models have to be able to exchange information with each other.

SWWRP Nutrient Module Development

Research Effort

To have a full system-wide water quality and contaminant capability in SWWRP, the different hydrologic and hydraulic engines must utilize a common water quality and contaminant approach to prevent the arbitrary portioning of constituents.

The goal of this research effort is to upgrade existing hydrologic and hydraulic models (i.e., water engines) using a common water quality approach in order to facilitate their linkage and application on a system wide basis.

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SWWRP Nutrient Module Development
Watershed Modeling System (WMS)

- Comprehensive system for watershed / reservoir modeling
- Extensive GIS import / export capabilities (ArcGIS, GRASS)
- Supports several models including
  - Rational Method
  - Flood Frequency Analysis
  - TR-20
  - HEC-1
  - HSPF
  - GSSHA
  - CE-QUAL-W2
- Widely used for civil and military applications
- Connectivity to surface and groundwater systems

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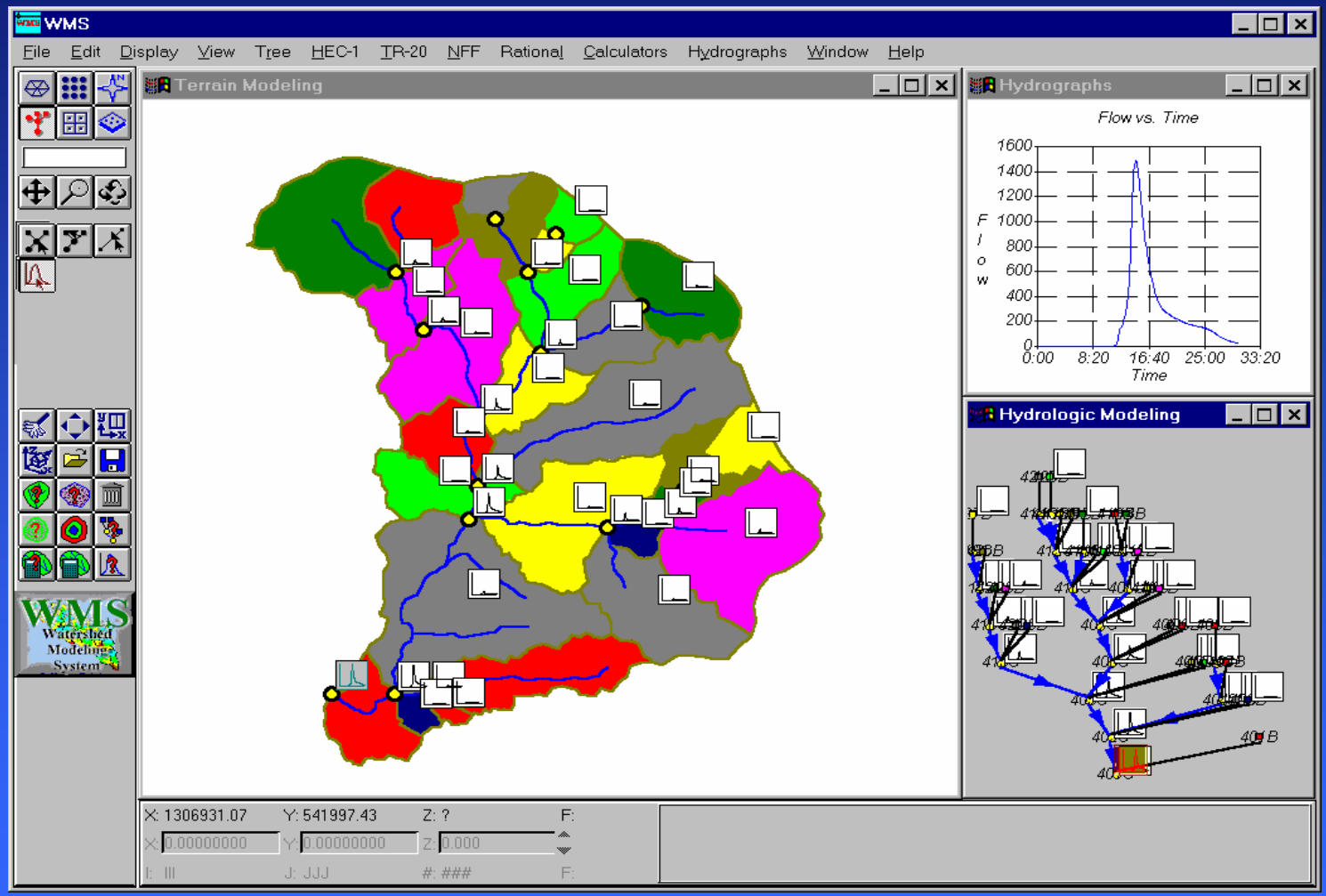
Watershed Modeling System (WMS)



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Watershed Modeling System (WMS)

- Import and analyze data - USGS and DTEDS DEMS, STATSCO soil data, USGS land use, rainfall, stream data, GIS coverages
- Delineate basins
- Delineate streams
- Provide input for hydrologic / reservoir models
- Create finite difference grids
- Create finite element meshes
- View model output and create animations

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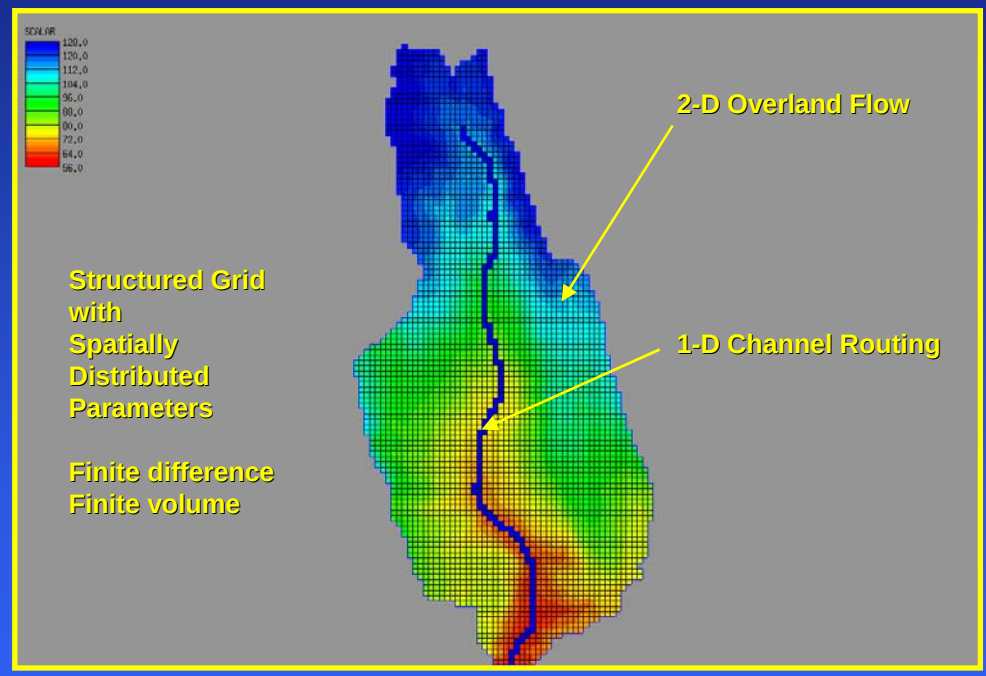
Gridded Surface Sub-surface Hydrologic Analysis (GSSHA) Model

GSSHA Flow and Sediment Modules

- **Spatial distribution of precipitation**
- **2D Overland flow (Diffusive Wave)**
- **1D Channel flow (Diffusive Wave)**
- **Infiltration (Green-Ampt, Green-Ampt Redistribution, and Richard's Eq.)**
- **Evapo-transpiration (Penman-Monteith and Deardorff)**
- **2D/3D Lateral groundwater flow**
- **Surface water/Groundwater Interaction**
- **Snow accumulation and melting**
- **Overland and channel sediment transport**
- **Overland and channel WQ transport**



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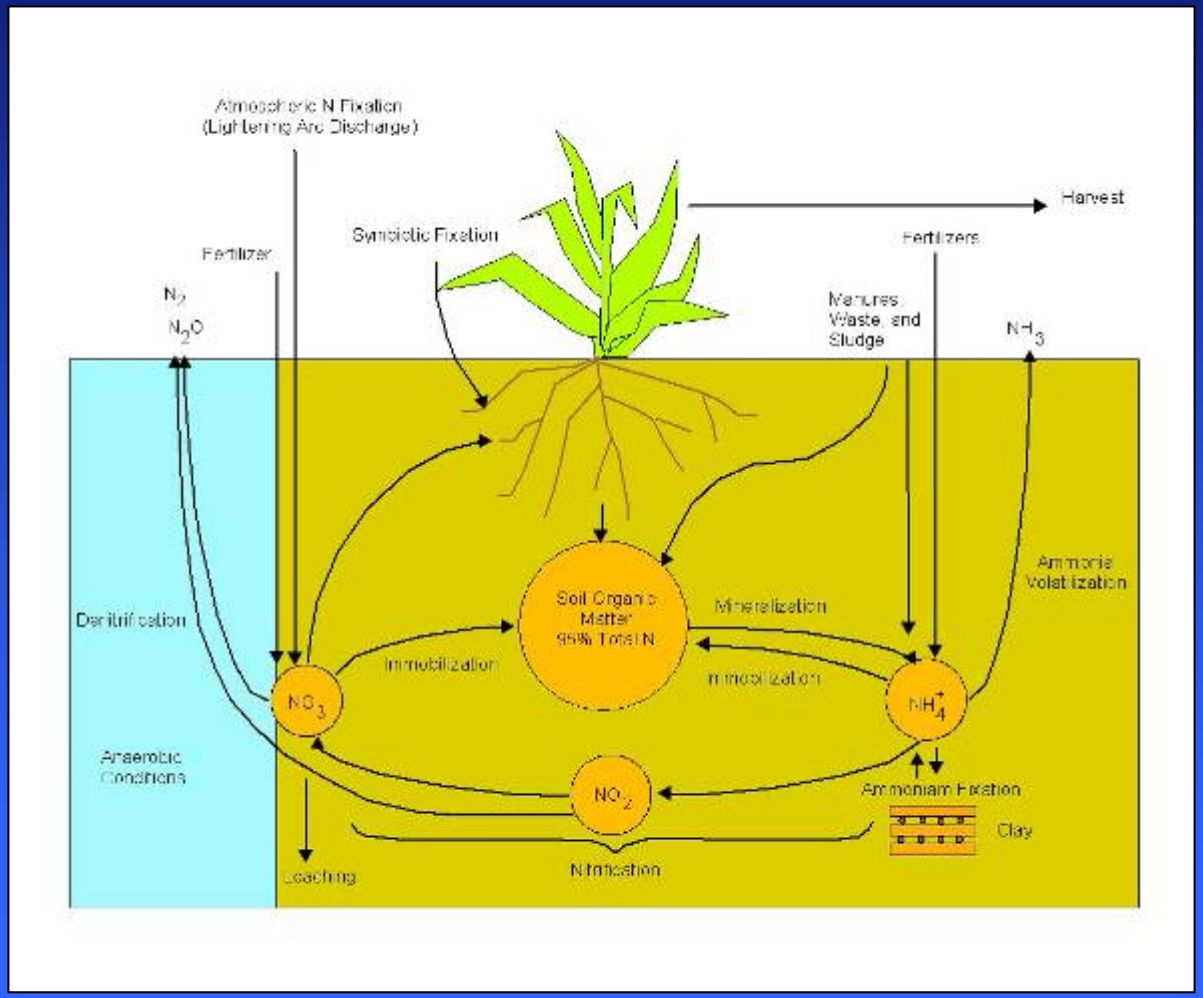
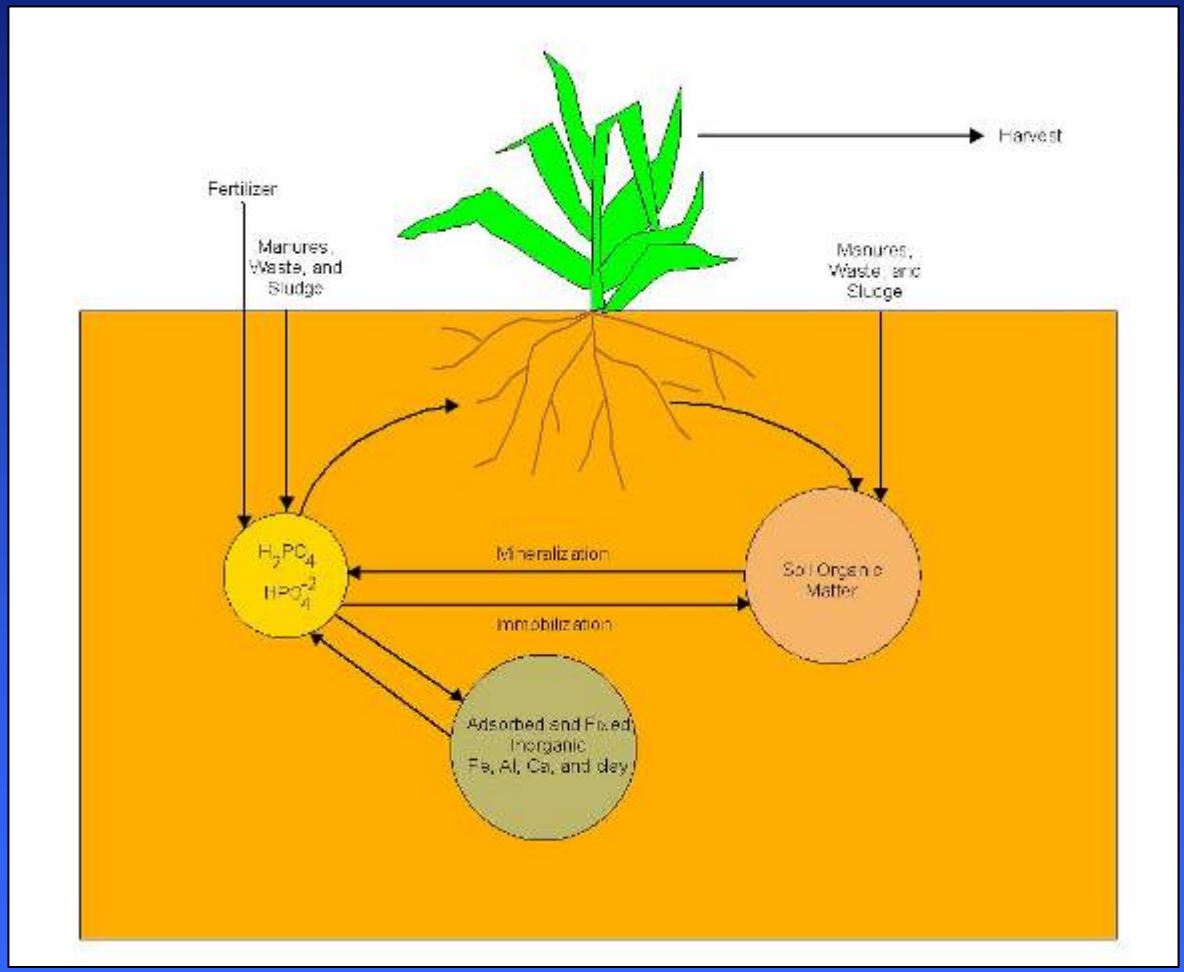
SWAT Nitrogen Cycle



SWWRP Nutrient Module Development

SWAT Phosphorus Cycle



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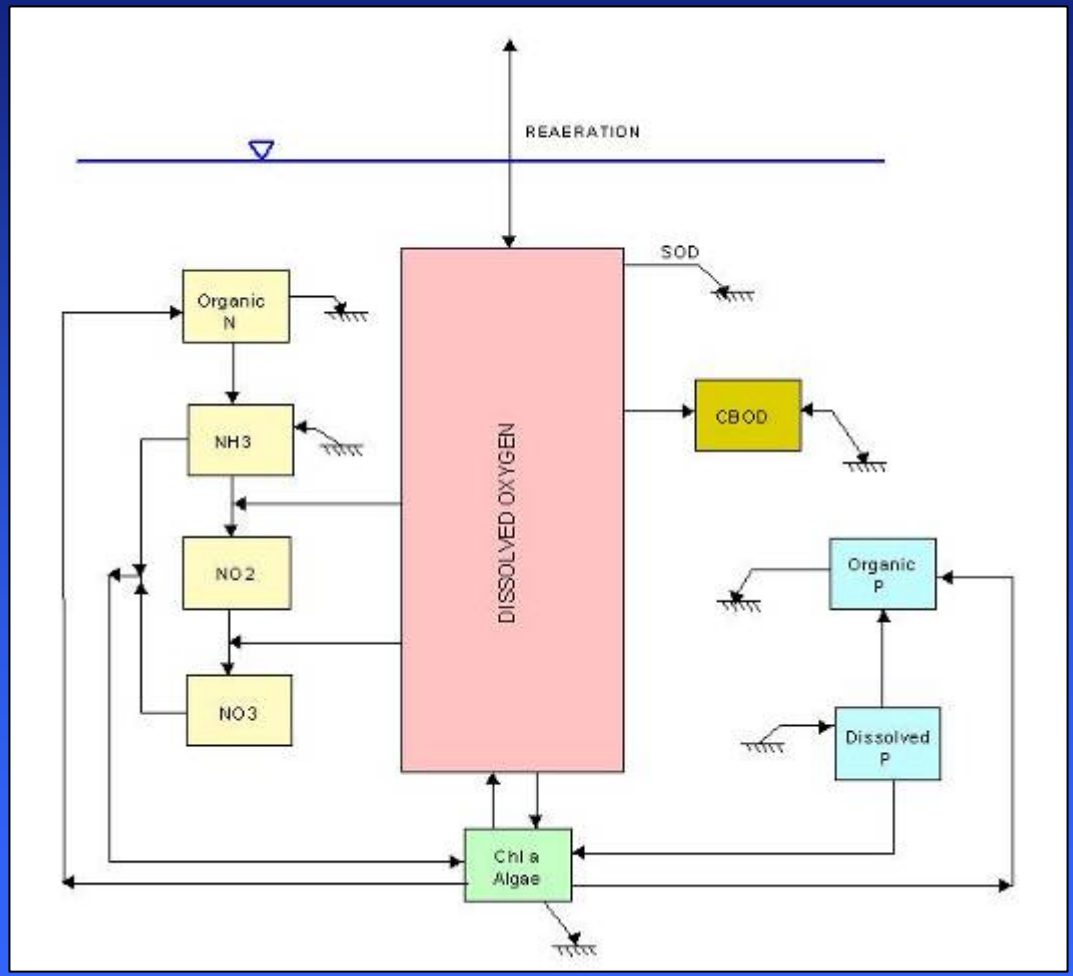
Channel Processes (Present) - QUAL2E WQ Cycle



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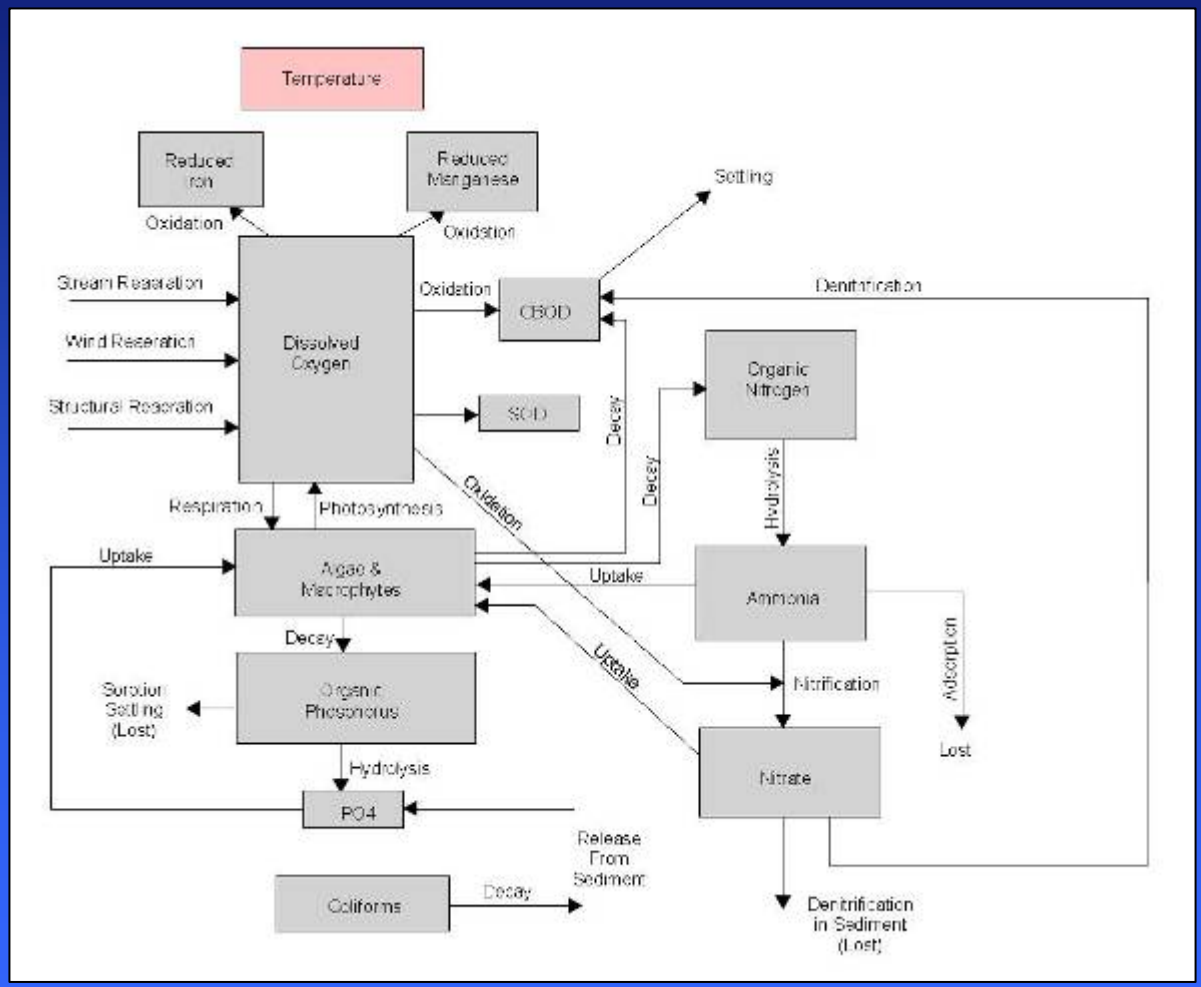
Channel Processes (Future) - RIV1 WQ Cycle



SWWRP Nutrient Module Development

Current Status

Currently, there exists overland and channel kinetics modules (SWWRP-NSMv1.0).

These modules allow for the input of: NO2, NO3, NH4, Organic Nitrogen, PO4, and Organic Phosphorus.

These modules allow for the output of: NO2, NO3, NH4, Org. N, PO4, Org. P, Algae, CBOD, and DO.

Constituents will be allowed to exist as dissolved, adsorbed, and/or solid phase where applicable. Presently, only dissolved form is transported.

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SWWRP Nutrient Module Development

Current Status

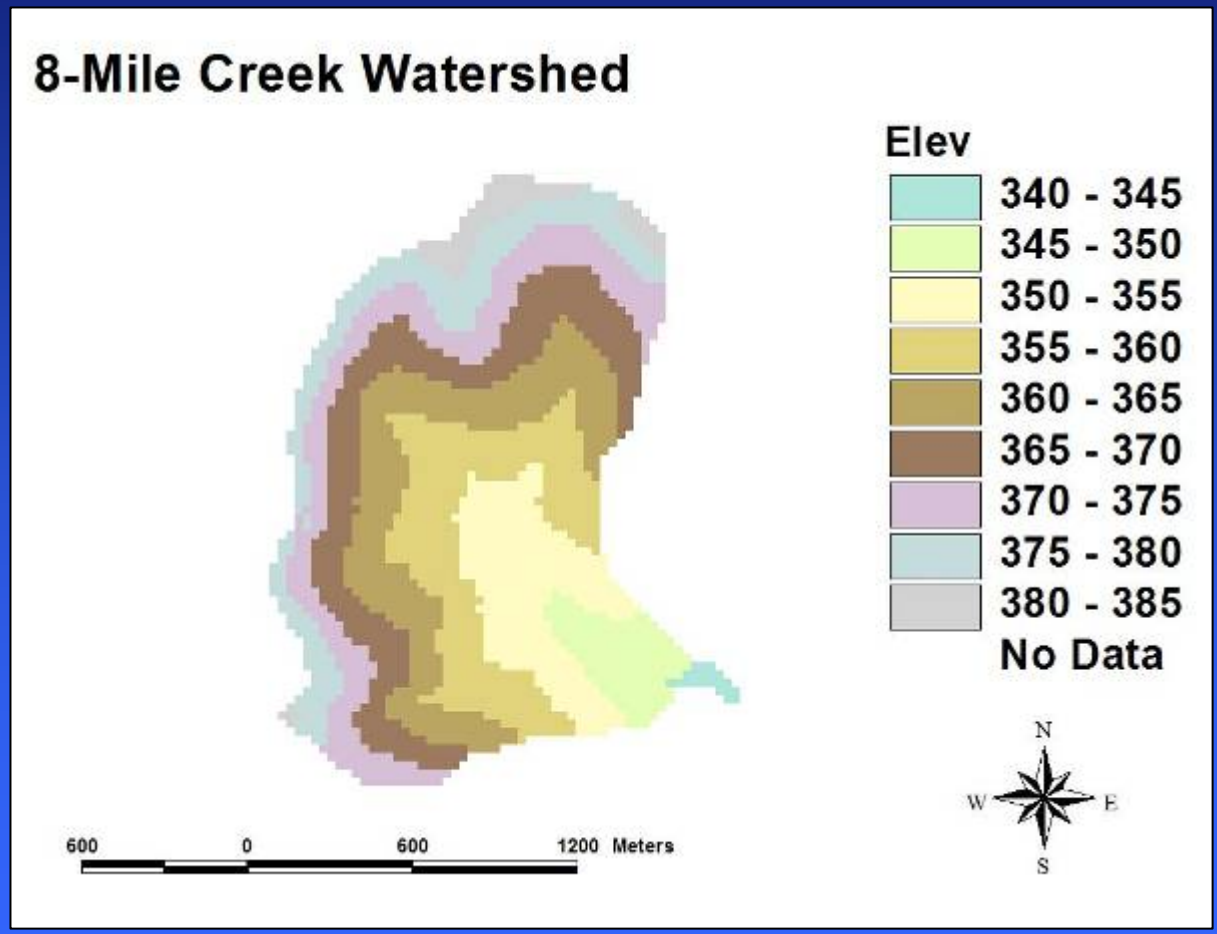
Overland and Channel Nutrient Kinetic modules are being linked with the GSSHA model.

Channel Nutrient Kinetic module is being linked with Hydrologic Engineer Center – River Analysis System (HEC-RAS).

SWWRP Nutrient Module Development

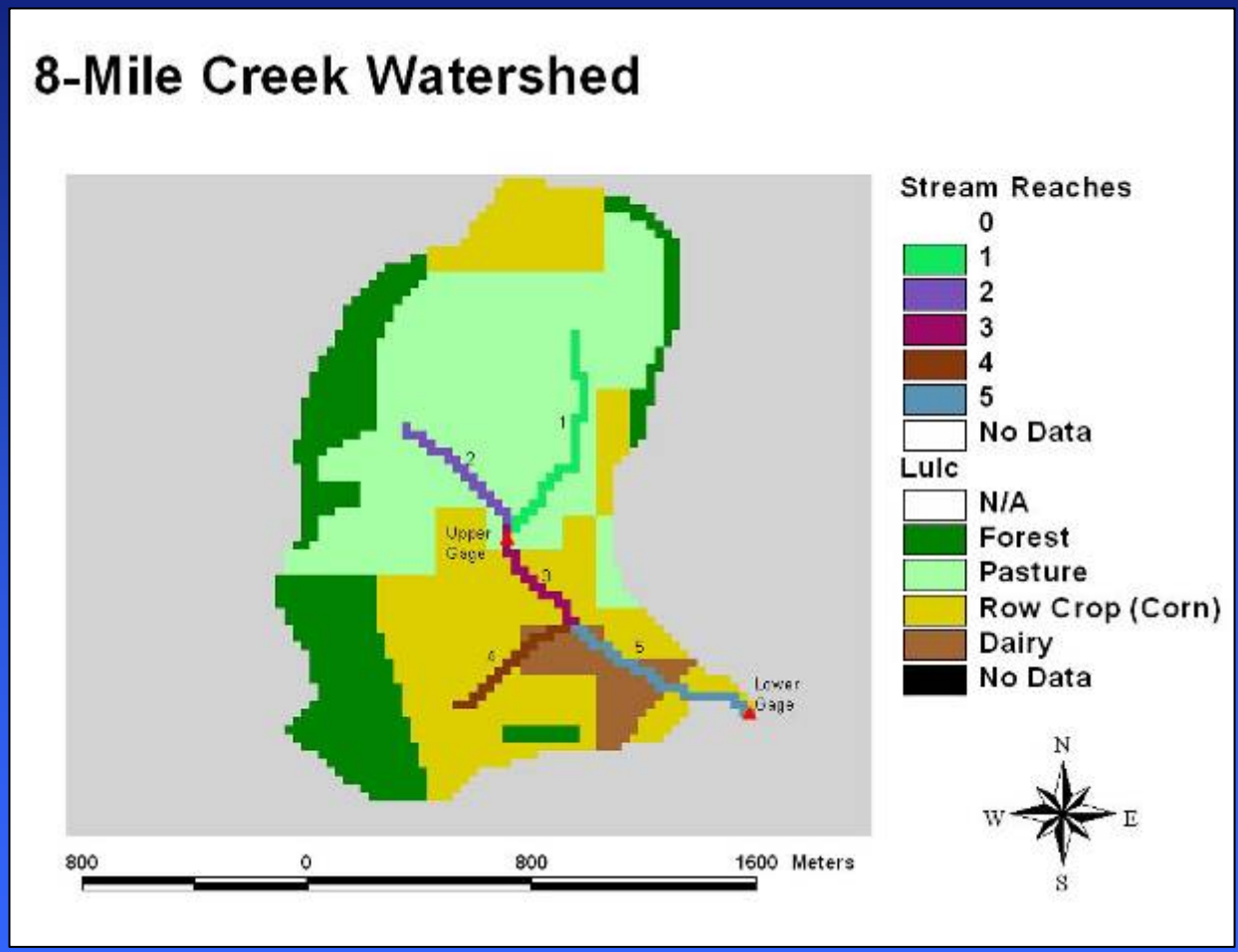
Validation Site: 8-Mile Creek Watershed

Drainage Area =
2.43 km^2 (0.88 mi^2)



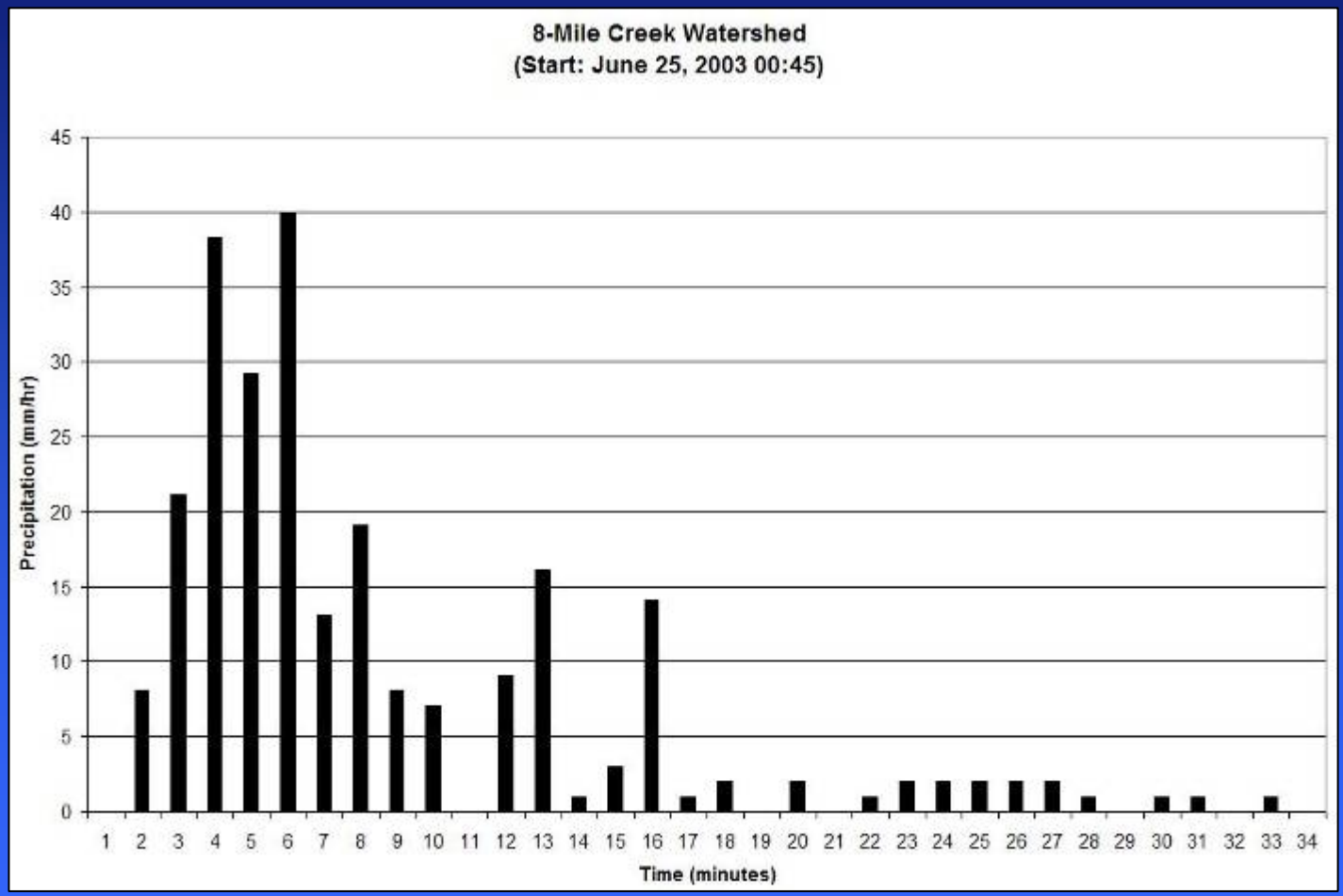
SWWRP Nutrient Module Development
Validation Site: 8-Mile Creek Watershed

Soil Texture is Silt Loam and is assumed to be uniform throughout the sub-area.



SWWRP Nutrient Module Development

Validation Site: 8-Mile Creek Watershed



SWWRP Nutrient Module Development

Validation Site: 8-Mile Creek Watershed

Flow Results

Runoff Volume (m^3)		% Difference
Observed Lower Gage	21074.3	-7.6
Simulated Lower Gage	19463.8	
Observed Upper Gage	11448.5	-5.6
Simulated Upper Gage	10811.1	
Time to Peak (min)		**% Difference**
Observed Lower Gage	345	13.0
Simulated Lower Gage	390	
Observed Upper Gage	315	-7.9
Simulated Upper Gage	290	
Peak Flow (m^3/s)		**% Difference**
Observed Lower Gage	0.79	0.0
Simulated Lower Gage	0.79	
Observed Upper Gage	0.72	-2.8
Simulated Upper Gage	0.70	

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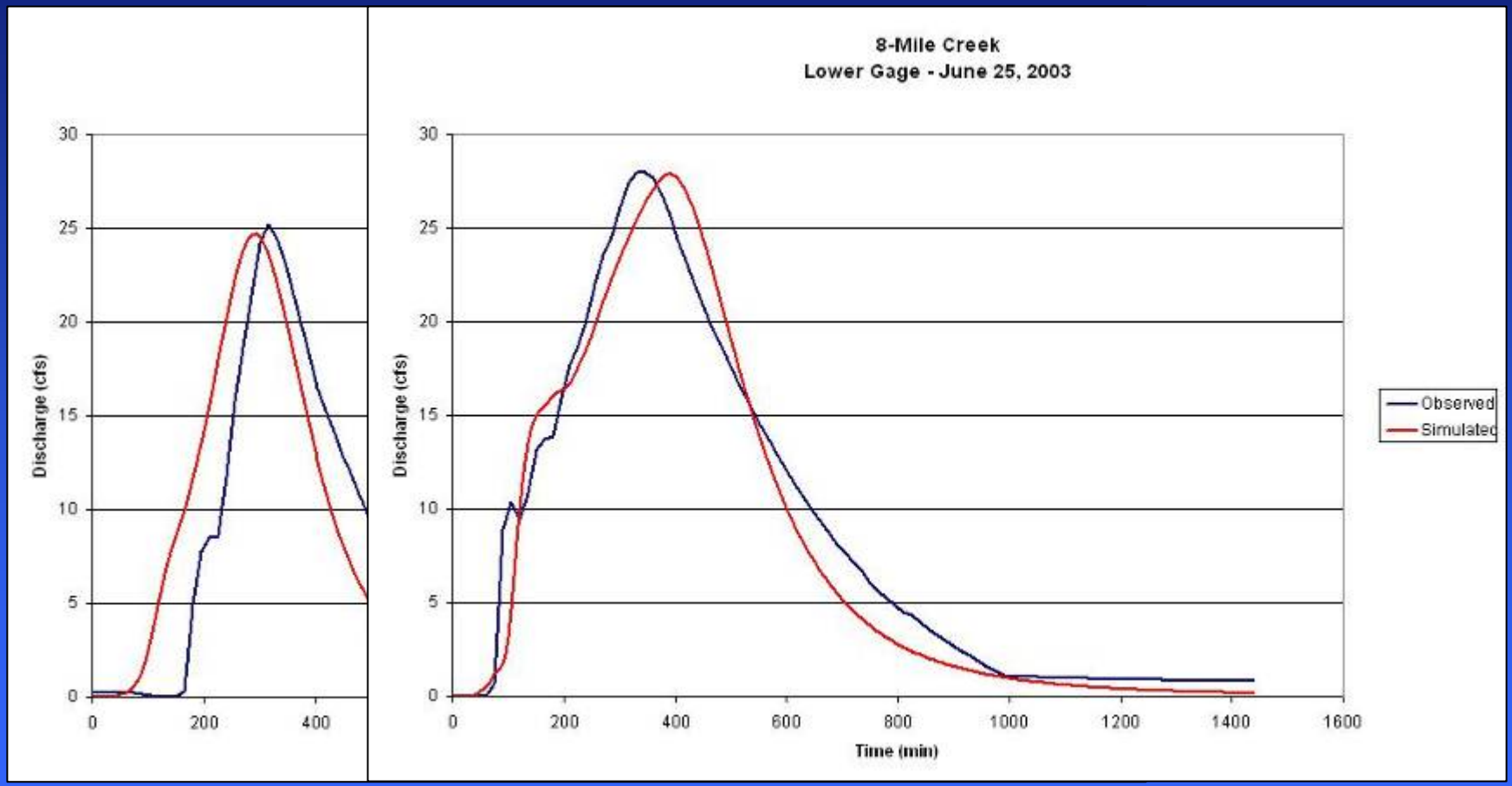
SWWRP Nutrient Module Development

Validation Site: 8-Mile Creek Watershed



SWWRP Nutrient Module Development

Validation Site: 8-Mile Creek Watershed

Nitrogen and Phosphorus Loading

Landuse	Soluble N (g)/(grid cell)
Dairy	192.6
Pasture	3.6
Corn	4.1
Forest	5.1

Landuse	Soluble P (g)/(grid cell)
Dairy	11.10
Pasture	0.67
Corn	0.95
Forest	0.24

- Assumed 95% of TN was Organic N.
- Assumed 0.1 cm effective depth for soil porewater.
- Assumed 1% of Organic N would be soluble.
- Assumed Specific Wt. of Soil would be 2650 kg/m^3.

- Used Sharpley's Slightly Weathered Equation to compute Labile P. Labile P = 0.56*BP+5.1 in ppm.
- Assumed a Kd value of 175 to compute Soluble P.

SWWRP Nutrient Module Development

Validation Site: 8-Mile Creek Watershed

Nitrogen and Phosphorus Model Results

Lower Gage	Soluble N (kg/d)
Total Observed Soluble N	163.8
Total Computed Soluble N	250.4
Upper Gage	**Soluble N (kg/d)**
Total Observed Soluble N	15.0
Total Computed Soluble N	20.8

Lower Gage	Soluble P (kg/d)
Total Observed Soluble P	12.4
Total Computed Soluble P	14.9
Upper Gage	**Soluble P (kg/d)**
Total Observed Soluble P	4.0
Total Computed Soluble P	3.5

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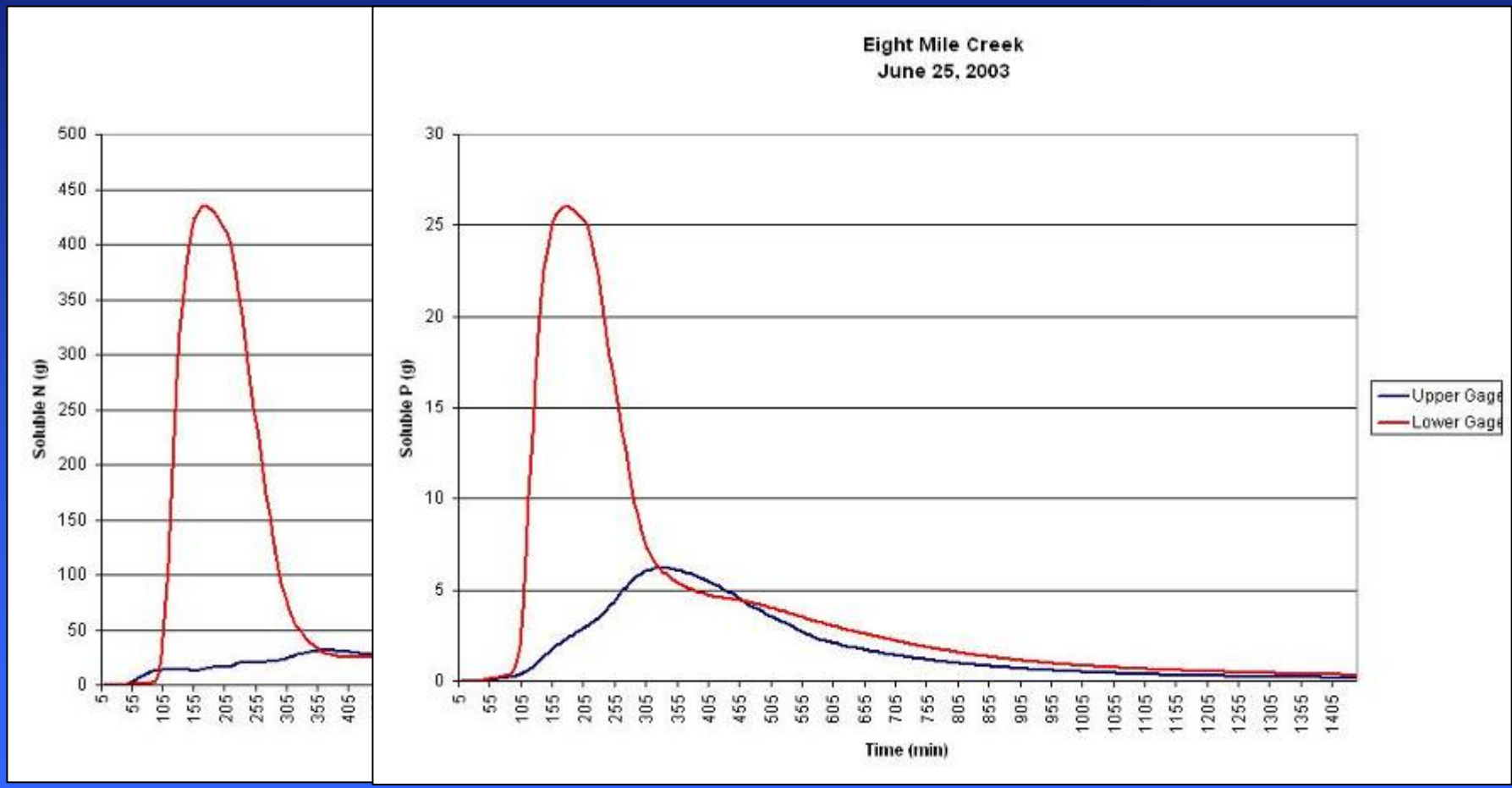
SWWRP Nutrient Module Development

Validation Site: 8-Mile Creek Watershed

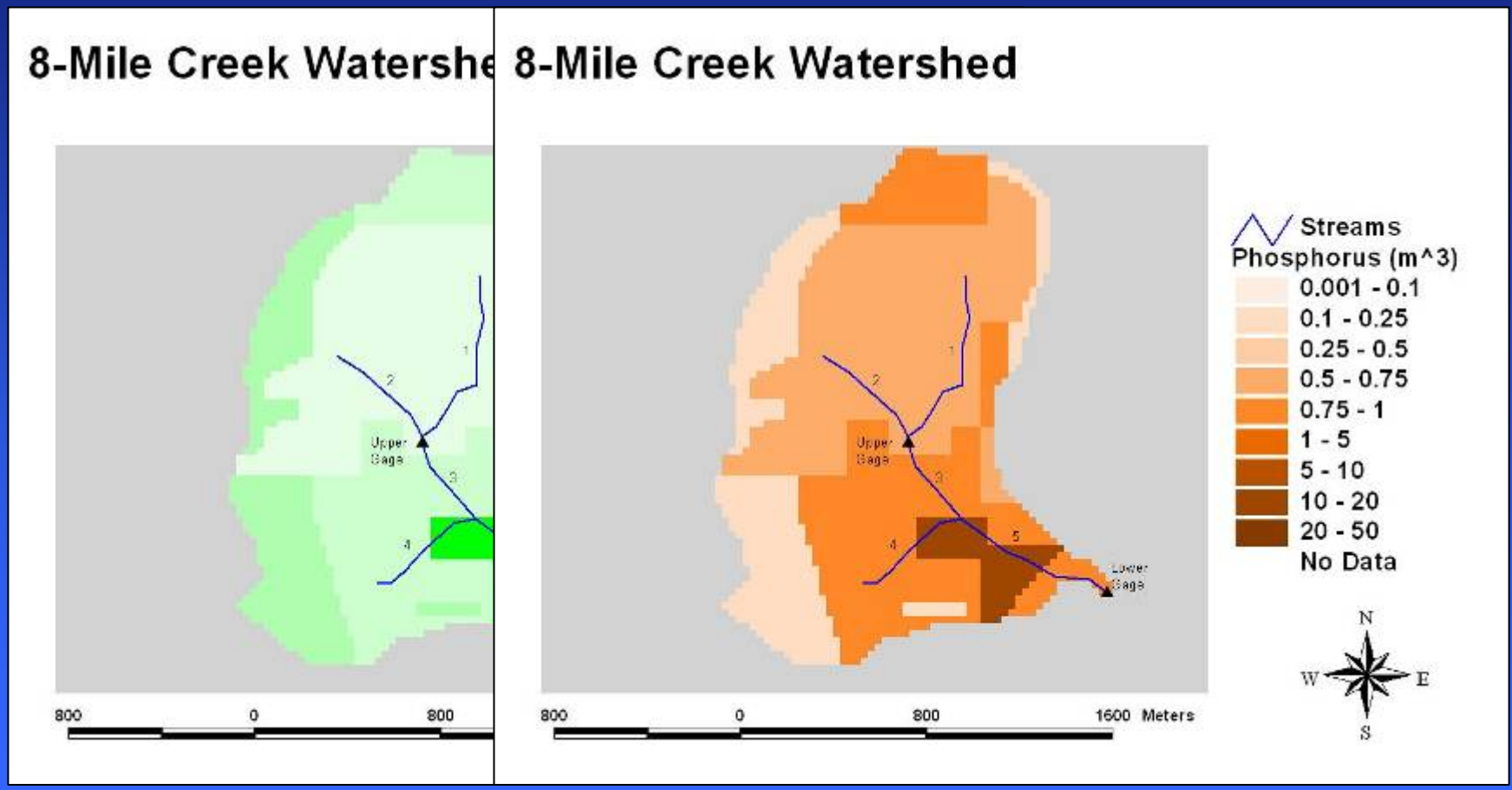
Nitrogen and Phosphorus Model Results



SWWRP Nutrient Module Development

Validation Site: 8-Mile Creek Watershed

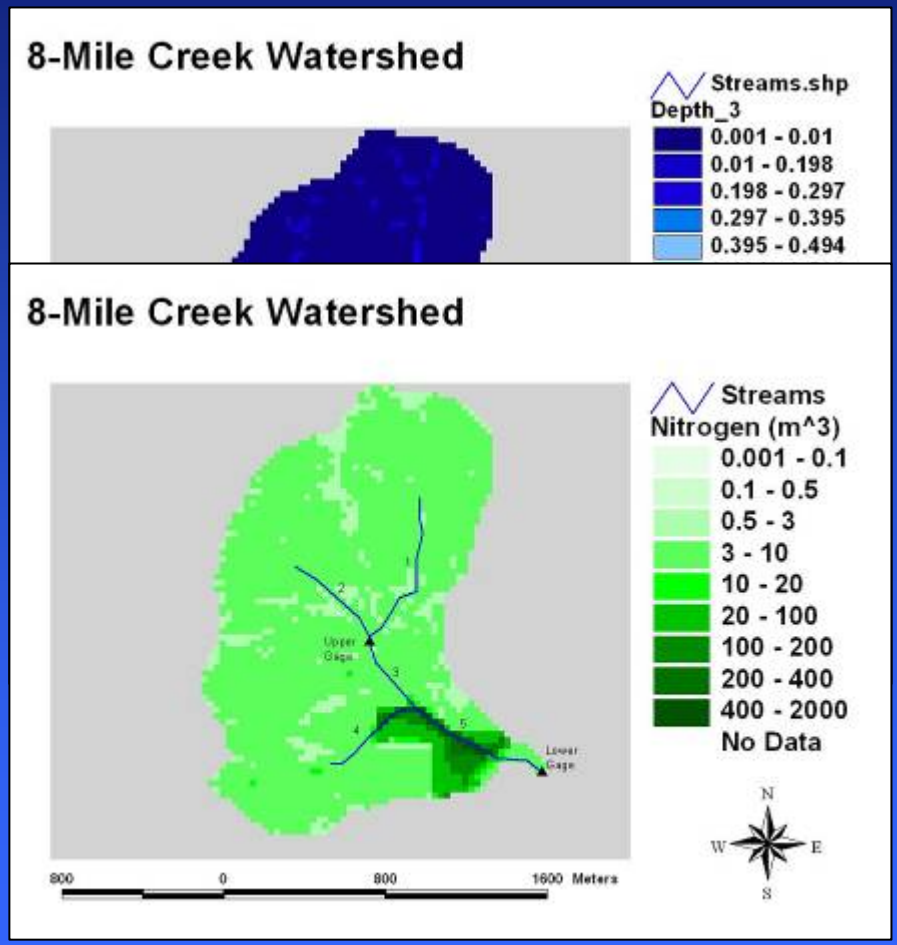
Nitrogen and Phosphorus Mass Loading Grids

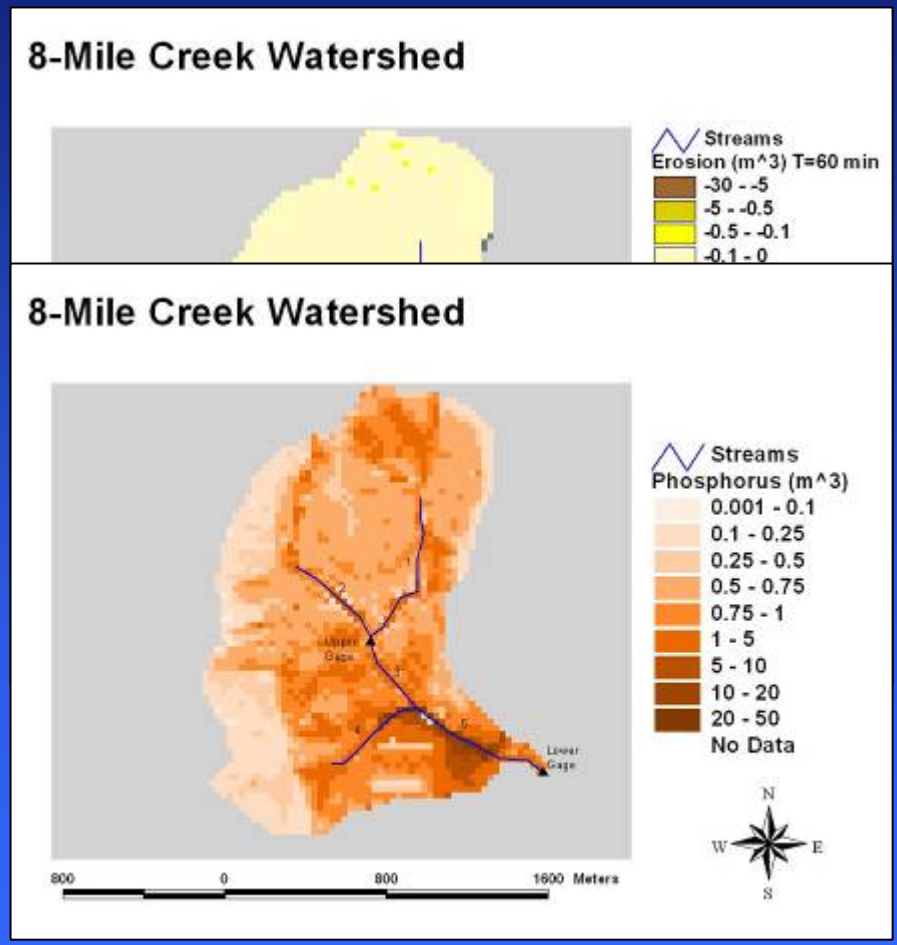


Eight Mile Creek Watershed

June 25, 2003

T = 60 minutes

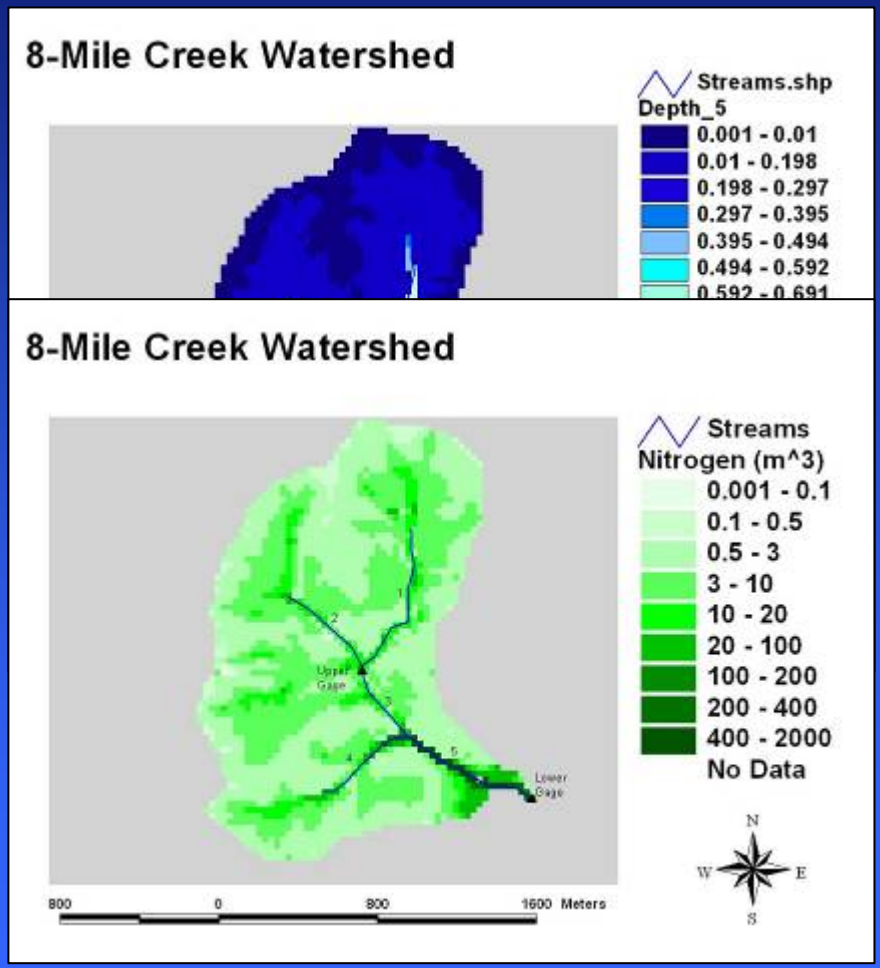




Eight Mile Creek Watershed

June 25, 2003

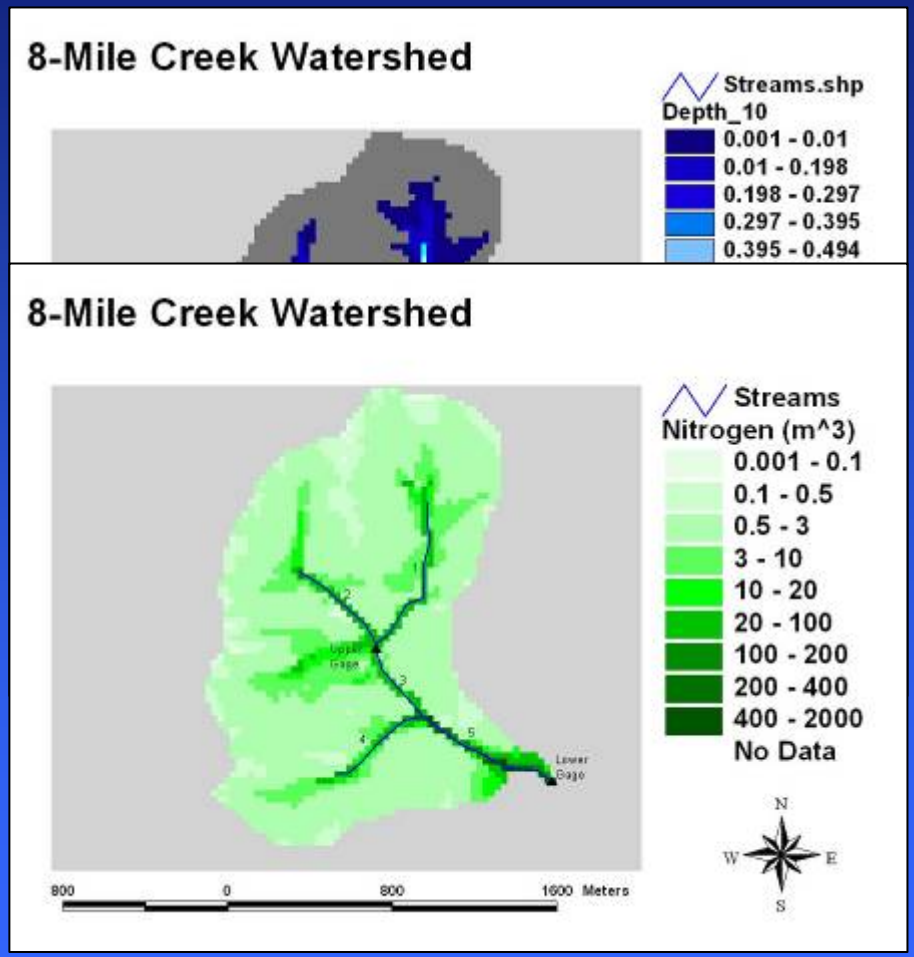
T = 120 minutes

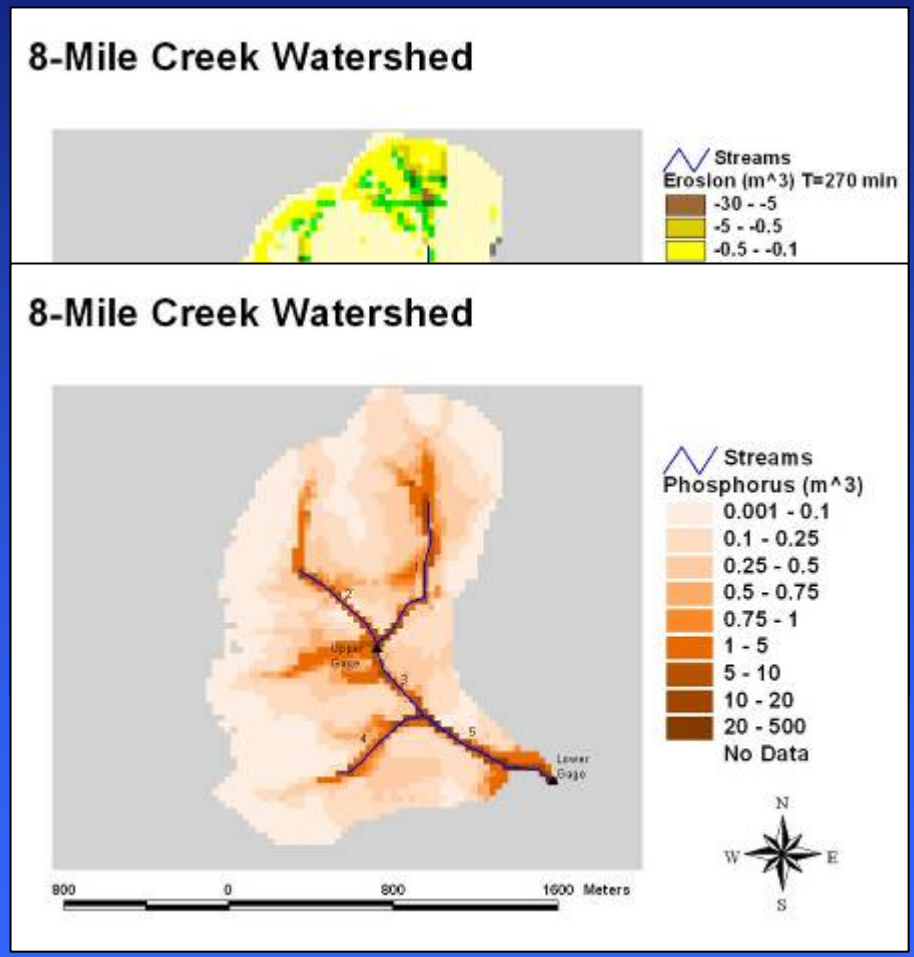


Eight Mile Creek Watershed

June 25, 2003

T = 270 minutes





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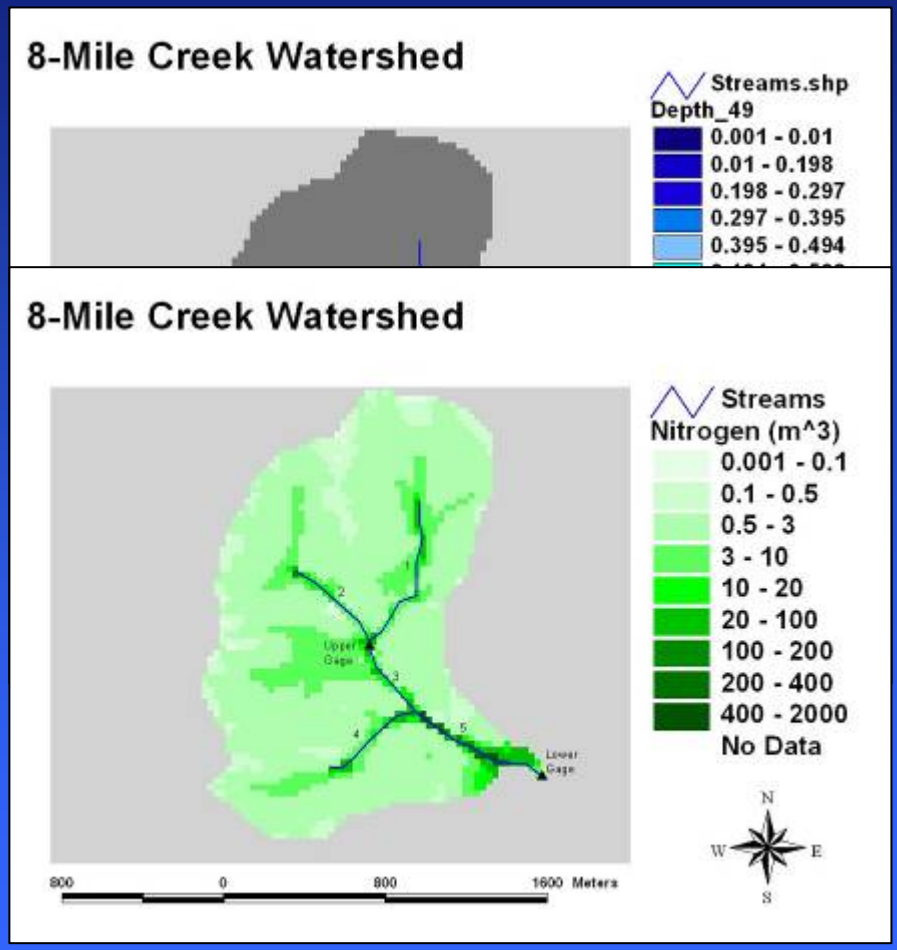
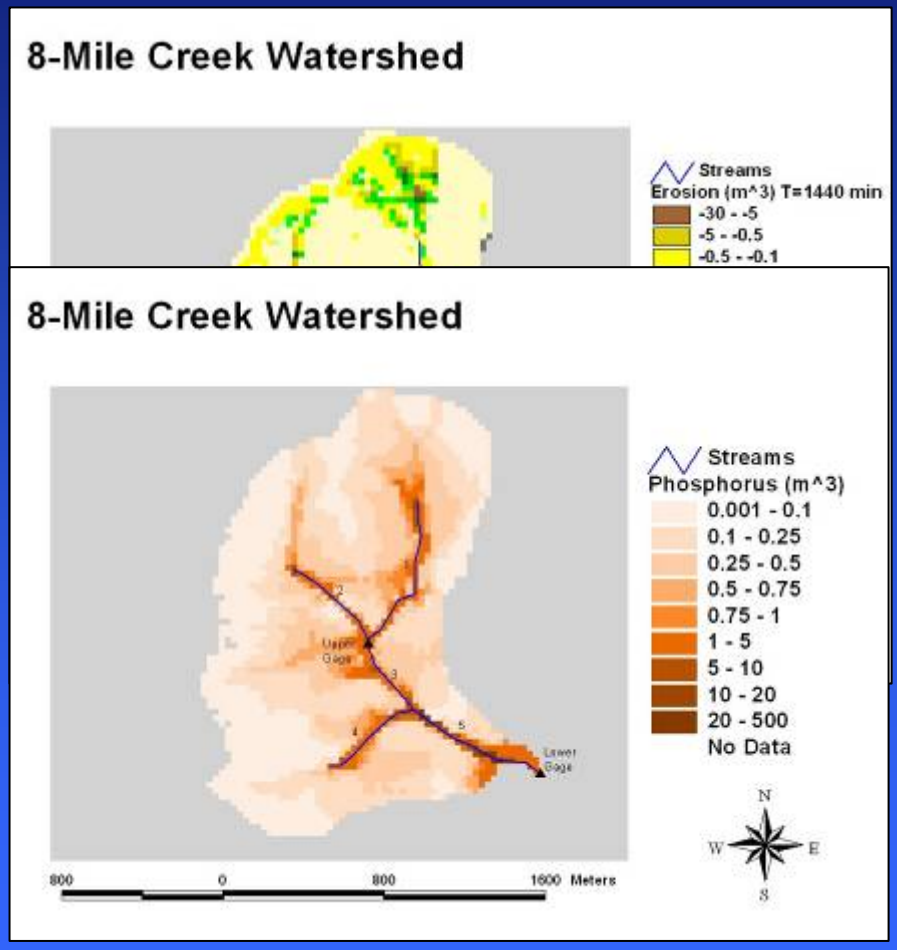
Eight Mile Creek Watershed

June 25, 2003

T = 1440 minutes





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SWWRP Nutrient Module Development
Future Development Activities

- Develop Plant/Soil Module
  - EPIC/SWAT Formulations
  - EDYS Formulations
- Upgrade Channel Kinetics to include RIV1 formulations.
- Develop Vadose Zone and Groundwater WQ fate and transport modules for linkage with various hydrologic and hydraulic models.

Questions ???

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